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Soil specific re-calibration of water content sensors for a field-scale sensor network

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Obtaining accurate soil moisture data from a sensor network requires sensor calibration. Soil moisture sensors are factory calibrated, but multiple site specific factors may contribute to sensor inaccuracies. Thus, sensors should be calibrated for the specific soil type and conditions in which they will be installed. Lab calibration of a large number of sensors prior to installation in a heterogeneous setting may not be feasible, and it may not reflect the actual performance of the installed sensor. We investigated a multi-step approach to retroactively re-calibrate sensor water content data from the dielectric permittivity readings obtained by sensors in the field. We used water content data collected since 2009 from a sensor network installed at 42 locations and 5 depths (210 sensors total) within the 37-ha Cook Agronomy Farm with highly variable soils located in the Palouse region of the Northwest United States.

First, volumetric water content was calculated from sensor dielectric readings using three equations: (1) a factory calibration using the Topp equation; (2) a custom calibration obtained empirically from an instrumented soil in the field; and (3) a hybrid equation that combines the Topp and custom equations. Second, we used soil physical properties (particle size and bulk density) and pedotransfer functions to estimate water content at saturation, field capacity, and wilting point for each installation location and depth. We also extracted the same reference points from the sensor readings, when available. Using these reference points, we re-scaled the sensor readings, such that water content was restricted to the range of values that we would expect given the physical properties of the soil. The re-calibration accuracy was assessed with volumetric water content measurements obtained from field-sampled cores taken on multiple dates. In general, the re-calibration was most accurate when all three reference points (saturation, field capacity, and wilting point) were represented in the sensor readings. We anticipate that obtaining water retention curves for field soils will improve the re-calibration accuracy by providing more precise estimates of saturation, field capacity, and wilting point. This approach may serve as an alternative method for sensor calibration in lieu of or to complement pre-installation calibration.